Exhibit A
SR-35 Columbia River Crossing Project
Modification # 5

Traffic and Roundabout Analysis

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INTRODUCTION

The following traffic study is to support advancement of the short-term conceptual design of the I-84/Hood River Bridge interchange identified in the DEIS process forward to the project development process. It is intended that the interchange design will accommodate the long term solution.

As part of Tier II of the SR-35 Columbia River Crossing Feasibility Study, traffic analysis was completed for base year and future (2025) conditions. Several future alternative scenarios were considered and a comparison drawn to the "No-Build" scenario. The options included "No-Build", intersections with signals, and roundabouts at the Interstate Highway 84 and State Route 35 (I-84/SR-35) interchange. Highway capacity analysis was conducted using micro-simulation models and corroborated with Highway Capacity Software-2000 (HCS-2000) analyses.

The current study focuses on roundabout analysis along with reviewing the previous traffic study results. A micro-simulation roundabout model was developed using VISSIM, a widely used tool for preparing transportation analyses including roundabouts. Two consecutive roundabout operations were studied in detail using both simulation and the FHWA's analytical methodology.

While Synchro/SimTraffic (version 6.0) models were developed to examine the impacts of queuing in the "No-build" and signalized intersection alternatives, the roundabout analysis used the FHWA analytical methodology (*1*) and the results were corroborated using Synchro/SimTraffic and VISSIM simulations.

PURPOSE

The purpose of this study is to prepare an in-depth review and analysis of roundabouts at the interchange. The study also reviews the existing traffic analysis that has been completed as part of Tier II of the project. This includes review of several alternatives developed to improve traffic operations at the I-84/SR-35 interchange to determine whether or not measures other than roundabouts should advance to project development.

ISSUES

This analysis follows and supplements the Draft Environmental Impact Statement (DEIS) for the replacement of the Hood River Bridge with a new, fixed-span bridge crossing. The issues which constituted the purpose and need for the bridge replacement project include:

- Current and future traffic delays and congestion, especially during peak hours for the I-84 ramp termini with the Hood River Bridge access road
- Structural conditions on the Hood River Bridge resulting in weight limits, causing delays or extended travel paths for freight crossing the Columbia River
- The narrow bridge (19 ½ feet wide) is substandard and results in a moderate to high risk of head-on and sideswipe accidents, as well as anecdotal evidence of vehicle mirror-to-mirror collisions already occurring on the bridge.
- The narrow bridge also presents a freight operations issue: when wide loads must cross the bridge, traffic needs to be stopped in the opposite direction to enable the wide load to cross the bridge

- The existing bridge has a substandard horizontal clearance for the navigation channel, which has resulted in reports of river traffic collisions with bridge piers.
- The existing bridge does not provide for bicycle and pedestrian crossings over the Columbia River.

Other issues that resulted from field investigations, other studies, and public comment include:

- There is limited sight distance due to bridge abutments for traffic exiting I-84 in both directions attempting to turn onto either the Hood River Bridge access road or toward Oregon 35.
- The I-84 overpass over the Oregon 35/Hood River Bridge access road is structurally deficient and has been included in the "cracked bridge" program for replacement.
- The narrow passage for the Hood River Bridge access road/Oregon 35 may conflict with the long-range improvement plans for the new Columbia River crossing and the bridge access road underneath I-84.

SUMMARY OF RECOMMENDATIONS

From the analysis of traffic for the SR-35 Hood River Bridge study area in 2025, urban roundabouts at the ramp termini and with the West Marina Drive/retail access road is the preferred concept. The attached conceptual design (Appendix A) details the design assumptions for the two roundabouts. To alleviate queuing at the eastbound ramp terminus, a potential "flare" or widening could be added at the intersection throat to allow for two vehicles to simultaneously enter the roundabout (one to turn southbound toward Button Junction, the other to travel around the roundabout to go northbound).

The roundabouts show acceptable LOS and queuing at both I-84 intersections. "No-build" or signalized intersection approaches will have operations at or near capacity and queues that will extend onto the I-84 mainline in the short-term future. It is recommended that the retail entrance be combined with westbound off-ramp into a composite roundabout. This is the best option due to the close proximity of this intersection to the westbound I-84 ramps, and the geometry of the two intersections will not allow feasible operations if both intersections are signalized.

STUDY AREA AND ASSUMPTIONS

The study area for analysis included SR-35 from Button Junction in the South to I-84, including the ramps, and extended across the Hood River Bridge to SR-14 in the North. The simulations developed for the alternatives included the I-84 ramps (EB On- and Off- ramp and WB On- and Off- ramp), the All Way Stop Control (AWSC) at West Marina Drive (Port Entry) and retail access, and the toll booth. It is assumed that the private driveway between the toll booth and retail access will be closed in the future for safety and traffic operations needs, and its traffic will shift to the retail access under future alternatives. Figure 1 shows the study area along with the intersections included in the study.

The tollbooth is located at the southern end of the Hood River Bridge and currently tolls are collected for both travel directions (two-way tolls). The Hood River Bridge is owned and operated by the Port of Hood River with a current toll charge of $0.75. For the purpose of current study, it was assumed that in the future tolls will be collected one-way southbound (under either build alternatives or medium-term 10-15 year alternatives). The assumption is primarily aimed at avoiding future queue spillovers at the I-84 eastbound and westbound off-ramps and SR-35 intersections. The Hood River Bridge can accommodate long queues due to its longer span.

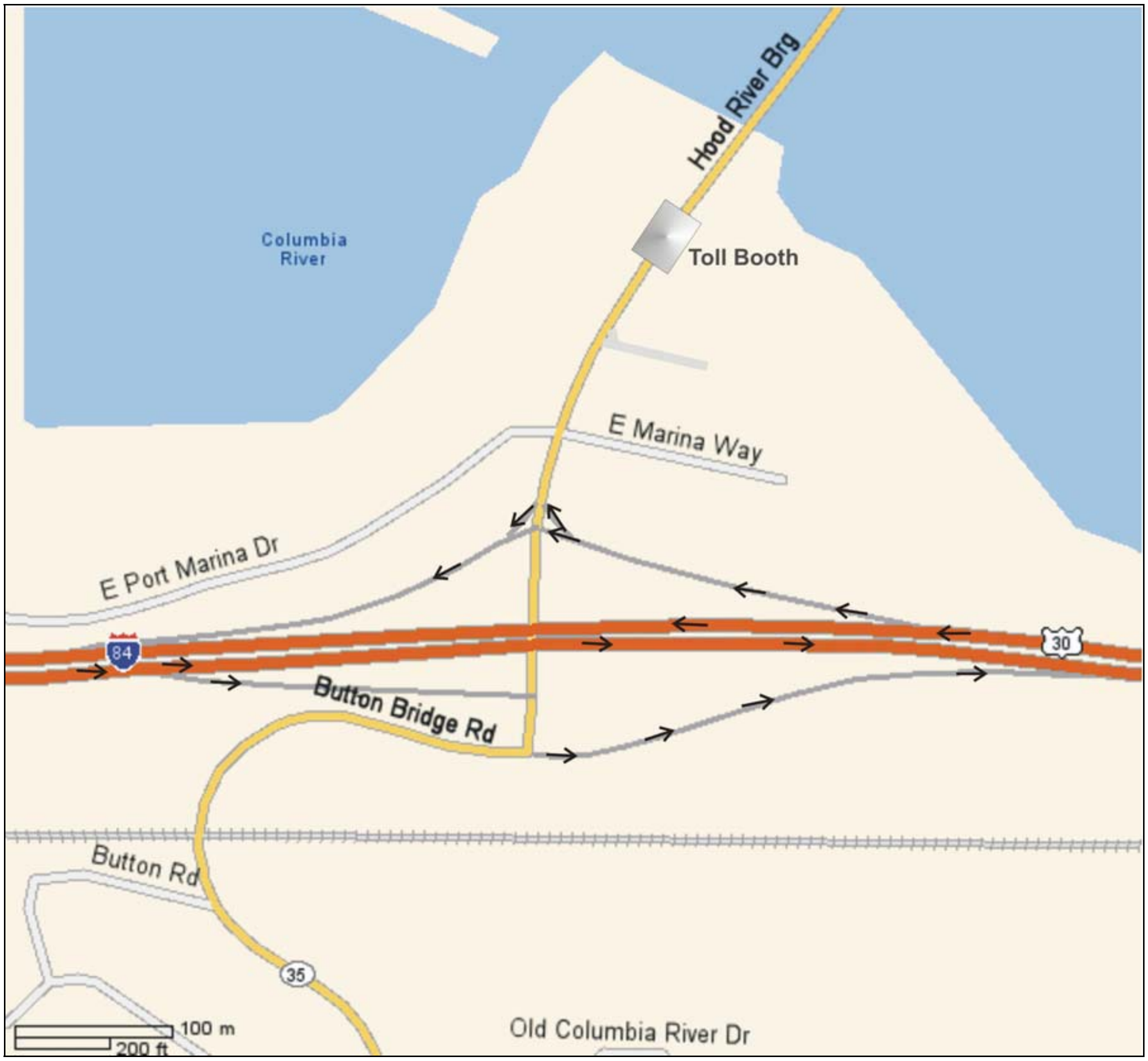

Figure 1: SR-35 Study Area

The SR-35 corridor is primarily two lanes. There are no separated pedestrian or bicycle facilities in the study area. In fact, pedestrians and bicyclists are restricted from the bridge.

The SR-35 Hood River Bridge is one of the nine bridges on the Columbia River along the Oregon/Washington border that provides north-south highway connections between the two major east-west highway systems – I-84 and Washington SR-14. I-84 is a major east-west highway on the Oregon side of the Columbia River; it connects Portland, Oregon to points east, such as Pendleton, Oregon and Boise, Idaho. SR-14 is a major east-west highway on the

Washington side of the Columbia River and is a National Highway System route that traverses both White Salmon and Klickitat cities. In addition, the bridge is the northern terminus of SR-35, which provides north-south access between the Columbia Gorge and Mt. Hood. The Hood River Bridge is one of the three bridges located in the Columbia Gorge National Scenic Area (CGNSA) and acts as an important crossing point for recreational travel within the CGNSA. The nearest available alternate river crossings are located 24 miles west of Hood River in Cascade Locks or 22 miles east of Hood River in The Dalles.

TRAFFIC ANALYSIS

Traffic patterns in the area around Hood River Bridge are influenced by three factors: the limited number of roads connecting with the bridge; the location of a majority of the jobs in the region on the south side of the Columbia River; and the differences in the tax structure between Oregon and Washington. The Washington sales tax provides an added incentive for Washington residents to do their major shopping south of the river where there is no sales tax. Traffic was studied for the area using micro-simulation models and HCS-2000. Simulation models using Synchro/SimTraffic 6.0 (Trafficware Corporation, 2003) and VISSIM 3.7 (PTV America, Inc.) were used to examine the impacts of queuing on I-84 and intersections along the design alternatives. These included SR-35 and I-84 eastbound, SR-35 and I-84 westbound, and SR-35 and retail/Marina Drive intersections. Degrees of saturation for the "No-Build" and signalized intersections alternatives were reviewed using HCS and for roundabouts using the FHWA methodology (*1*). The analysis began by reviewing base year and future (2025) traffic volumes and other related information available for the study area.

Existing and Future - 2025 Volumes

Existing traffic counts from year 2000 were used for the base year for the PM peak hour. Using historical counts, population and employment growth projections and the origin-destination survey conducted by RTC, future travel forecasts for future year 2025 were developed by Parsons Brinckerhoff for the SR-35/Columbia River Crossing Draft EIS (*2*). Base year traffic data for West Marina Drive-Market Place/SR-35 intersection were estimated using the ITE Trip Generation Manual (*3*). Future volumes for the market place were assumed to be constant with respect to the base year and that for the West Marina Drive were assumed to grow at approximately half the rate of I-84/SR-35 intersections. It was assumed that land-use for the Market Place will remain the same since the available land is at full build-out and no additional retailers/other land-uses could be accommodated in these parcels.

The analysis was limited to the peak hour of travel for the weekday PM peak hour. From traffic counts, the peak direction of travel was the northbound direction. Traffic composition for the study area was based on the Hood River Bridge Origin and Destination Survey-1990 for most approaches. Details and assumptions on estimated traffic volumes, traffic composition and the Peak Hour Factor (PHF) for the study area are in Appendix B.

Review of Alternative Scenarios

The base year (2000) congestion levels in the vicinity of the Hood River Bridge are relatively low. The Hood River to Mt. Hood, SR-35 Corridor Plan notes that while the traffic volumes in the corridor have been growing there are few congestion problems. The highest level of congestion along the Hood River corridor occurs at the East Hood River Interchange where the

SR-35/Hood River Bridge access roadway intersects the I-84 access ramps. These intersections both have a moderate level of congestion (Level-of-service (LOS) D/E) with left turn movement delays of over 40s/veh (*2*). In the base year, the I-84 off-ramps operate as Two Way Stop Controlled (TWSC) intersections and the West Marina Drive (Port Entry)/retail access operates as an All Way Stop Control (AWSC) intersection.

The three future alternatives study analyzed were “No-Build 2025”, Signalize – Build Alternative 1, and Roundabouts – Build Alternative 2. The assumptions used for developing the alternatives are located in Appendix B. Using Year 2025 forecasts for the PM peak hour, degree of saturation (V/C ratio) and delays were determined by traffic-movement and approach for each alternative. For the “No-Build” and the Signalize options, this was done by developing the model first in Synchro and then exporting the data to HCS-2000. For roundabouts, the FHWA methodology was used. Intersection performance results by design alternatives are shown in Table 1.

Table 1: 2025 Intersection Performances by Alternatives

No.	Intersections along SR-35	Design Alternatives								
		No-Build			Signalize			Roundabout		
		V/C Ratio	Delay (s) / LOS	95% Queue Range (ft)	V/C Ratio	Delay (s) / LOS	95% Queue Range (ft)	V/C Ratio Range	Delay (s)	95% Queue Range (ft)*
1	I-84 EB On-Ramp	0.32	13.3 / B	50 - 75	0.86	42.6 / D	150 - 975	0.32 - 0.86	21.40	275.00
2	I-84 EB Off-Ramp	1.45	282 / F	25 - 975						
3	I-84 WB On- and Off-Ramp	0.59	41.1 / E	25 - 375	0.66	14.8 / B	100 - 525	0.07 - 0.88	21.46	325.00
4	W. Marina Dr./retail	0.85	280 / F	50 - 200	0.85	280 / F	25 - 150			

*Note: Assumes average vehicle length of 25 feet.

Note that in Table 1, 95% queue lengths for the “No-Build” and the Signalize options were obtained from SimTraffic. Due to the variations in results of micro-simulation models, 3 runs were conducted and averaged in order to achieve more accurate estimates on the true performance measures. Past research in this area shows that as a general guideline, at least 2 runs are needed under any capacity condition to achieve more accurate estimates (*4*).

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

A detailed discussion of results by alternative is presented below:

No – Build

- Each of the intersections operates at near failure or LOS E-F conditions overall. Both I-84 off-ramps experience large queues as the drivers wait to get turn onto SR-35.
- The queues at I-84 off-ramps extend onto the freeway that would likely affect freeway operations.
- The minor left-turn (off-ramp) has a LOS F and V/C ratio of 1.6.
- Queuing at the toll booth is significant in both directions of traffic and is a problem for the northbound direction as vehicles start to spillback into the intersection where retail

shops and the Marina Center have access. During peak times, the queues even back up into the freeway ramp intersection.

Screen shot shown in Figure 2 also help clarify the extent of queuing that would occur under the No-Build scenario.

Signalize – Build Alternative 1

- No lane-group in either of the signalized intersections is designated as LOS F, as delays remain under 80.0s/veh, the maximum for LOS E. Signalizing the I-84 intersections decreased control delays and improved LOS versus No-Build option.
- I-84 eastbound off-ramps left-turn movement shows a delay of 55.4s/veh with a LOS E. The V/C ratio is 1.02 and queues extend beyond the ramp onto the freeway. Although the intersection's performance could still be improved by reallocating green times, delay reduction will be minimal because the critical elements are close to capacity.
- Operations at the I-84 westbound off-ramps show significant improvement with signalizing the intersection. The minor left-turn (ramp) movement shows a delay of 30.6 seconds and a LOS C. The V/C ratio is 0.25 for the left-turn movement.
- Northbound SR-35 through traffic shows the highest V/C ratio of 0.70. However, the delay for this movement of traffic is only 2.0 sec/veh and LOS A.
- The West Marina Drive/retail access intersection was retained as all-way stop control (AWSC). The operations do not change at this intersection with signalizing the I-84 ramp intersections. Queue lengths may vary depending on traffic platooning and arrivals.
- The conversion to one-way tolls southbound eliminates toll-booth queue spillovers into the West Marina Drive/retail access intersection.

Screen shot shown in Figure 3 helps in clarifying the extent of queuing that would occur under the Signal option.

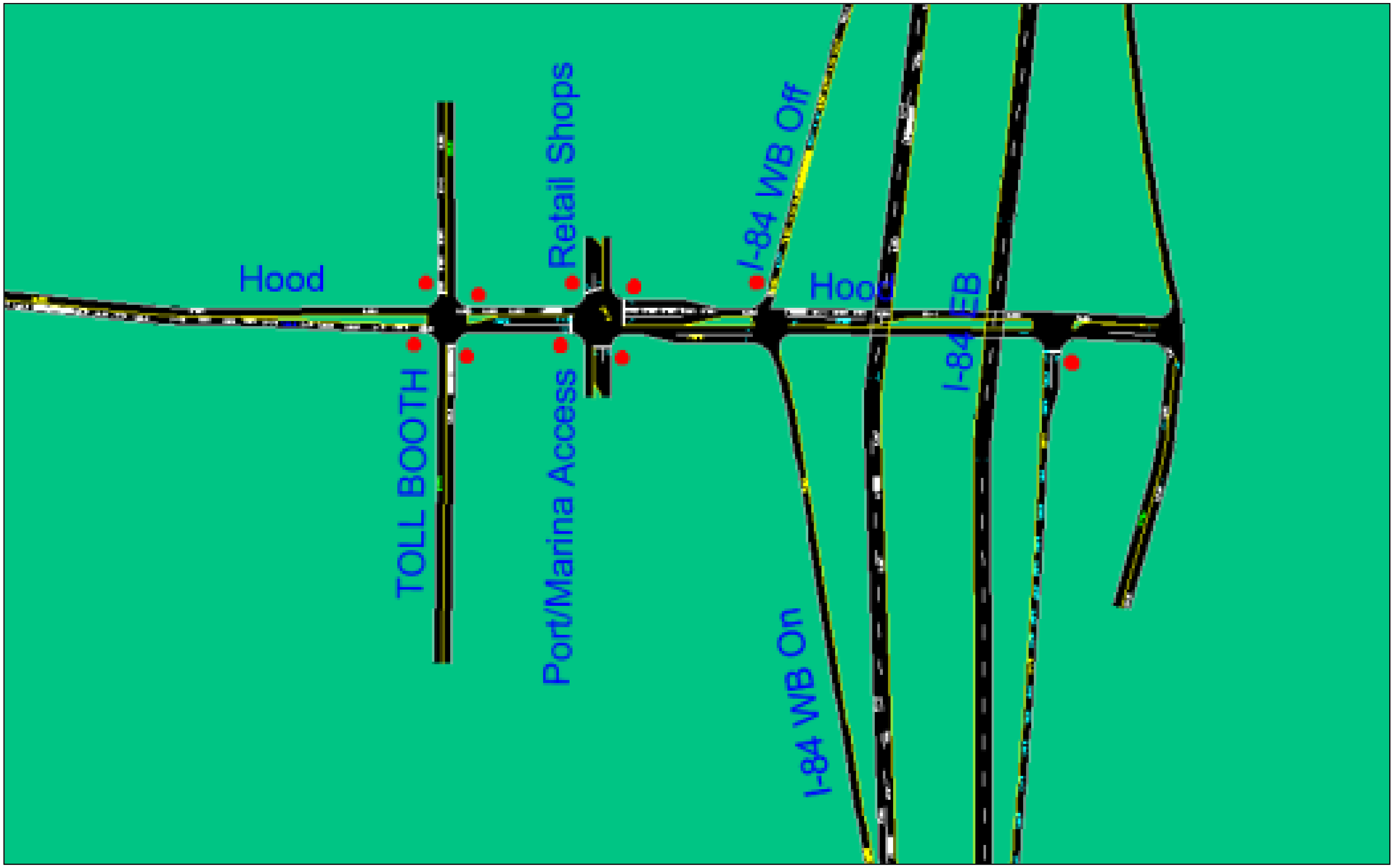

Figure 2: SimTraffic Micro-Simulation for No-Build 2025

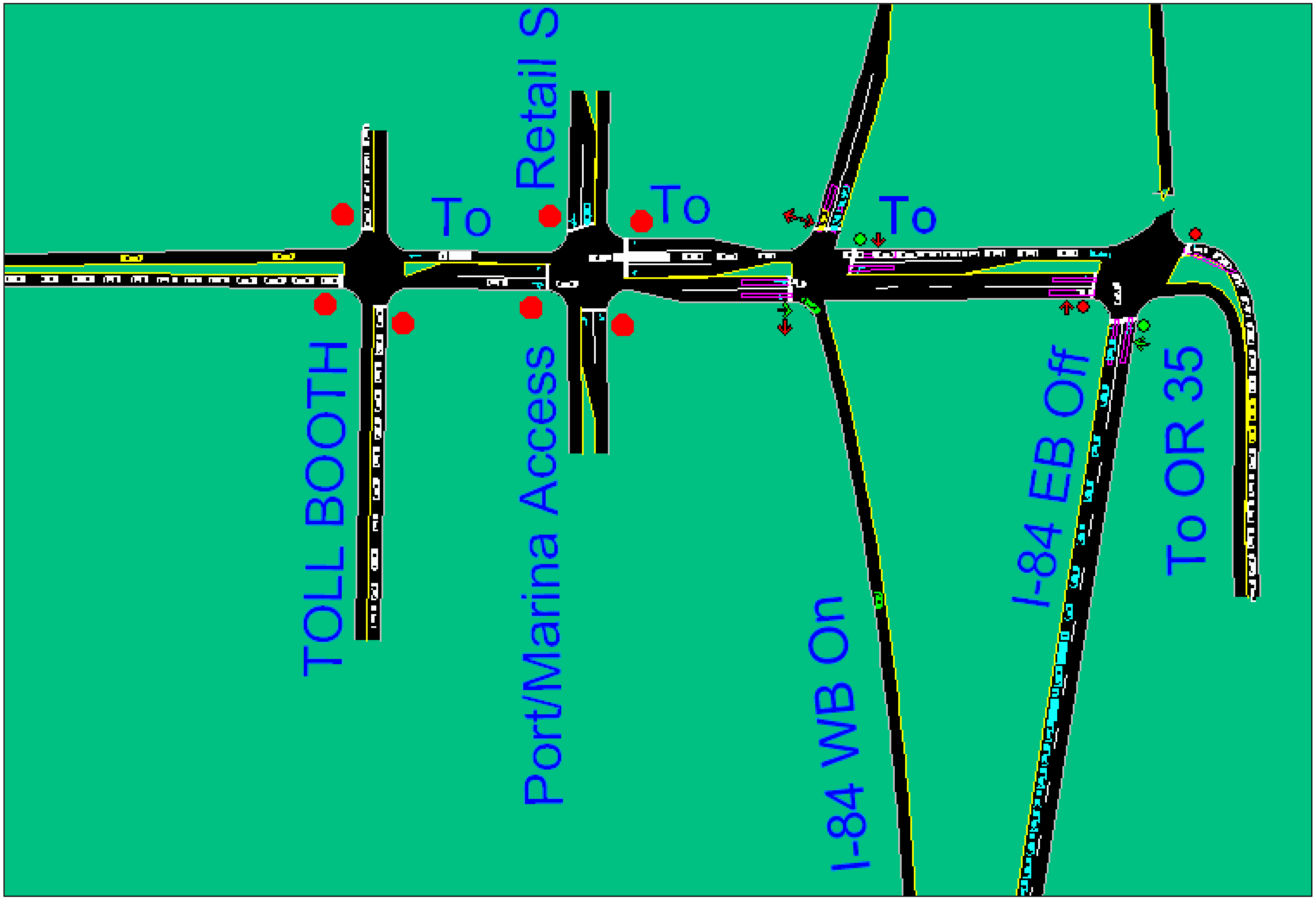

Figure 3: SimTraffic Micro-Simulation for Signalized Intersections

Figure 4: VISSIM Micro-simulation for Roundabouts

Single-lane Roundabouts – Build Alternative 2

- The roundabout at the I-84 eastbound ramps has 4-legs for SR-35 and I-84 ramps. The critical approach is the I-84 off-ramp with V/C ratio of 0.86. Other approaches show V/C ratios less than 0.6. The I-84 off-ramp approach will operate slightly over-capacity since the desirable maximum V/C ratio is 0.85. This means that this approach may show increased delay and queuing during peak times. As per FHWA guidelines for roundabouts, the circulating flow at any point in this single-lane roundabout does not exceed 1,800veh/h, the threshold for double-lane entry. Double-lane exits are also not recommended for this intersection because exit flows for any approach do not exceed 1,200veh/h, the maximum for single-lane exits.
- The I-84 eastbound roundabout critical lane delay is 21.4 sec/veh with the 95% queue expected to be at 275 feet.
- The oval roundabout combines SR-35, the I-84 westbound ramps, and the West Marina Drive/retail access. The critical approach is northbound SR-35 with a V/C ratio of 0.88. The other approaches operate within the V/C ratios of 0.07 and 0.61. The circulatory flow ranges between 152veh/h to 1066veh/h and is below 1,800veh/h threshold for double-lane entry. The exit flows range between 65veh/h to 1036veh/h and are also below the threshold of 1,200veh/h requiring double-lane exits.
- Oval roundabout shows critical lane delay of 21.46sec/veh and the 95% queue extending over 325 feet.

The screen shot shown in Figure 4 shows the extent of queuing that would occur under the Roundabouts option. Detailed calculations for capacity, delay, and queuing for roundabouts are shown in Appendix C. For the two critical approaches (i.e. I-84 eastbound off-ramp of the first roundabout and northbound SR-35 of the oval roundabout), it is recommended that the approaches be flared to accommodate 2 vehicle short lanes. Short lanes are the additional partial lanes added when flaring a roundabout from one to two lanes. This can help in maintaining operations below the critical level. Results after such a modification show a V/C ratio of less than 0.6 at both the legs.

Conclusions and Recommendations

From the analysis of traffic for the SR-35 Hood River Bridge study area in 2025, urban flared roundabouts would be the best alternative. Roundabouts show acceptable LOS and queuing at both I-84 intersections. “No-build” or signalized intersection approaches will have operations at, or near capacity and queues that will in turn affect free-flowing traffic on I-84. It is recommended that the retail entrance be combined with westbound off-ramp into a composite roundabout. This is the best option since westbound off-ramp and Market Place intersections are in close proximity to each other and the geometry of the two intersections will not allow feasible operations if both intersections are signalized. Nor will it be operationally acceptable to let the Market Place intersection operate as AWSC in 2025, as seen in Build Alternative-2.

Generally, roundabouts are cheaper to build and maintain than signalized intersections. Roundabouts may require more right-of-way than traditional intersections controlled by traffic signals or stop signs. Most of the regular maintenance costs of roundabouts are related to landscaping, lighting, and standard roadway maintenance (e.g. snowplowing, street cleaning). As part of the current study, the cost of constructing roundabouts at the two I-84 intersections was estimated to be under $1.0 Million. The break-up of costs is shown in Appendix D. The total cost does not include allowance for environmental mitigation. The roundabouts' designs were based on FHWA requirements. The attached conceptual design (Appendix A) details the design assumptions for the two roundabouts. To alleviate queuing at the eastbound ramp terminus, a potential "flare" or widening could be added at the intersection throat to allow for two vehicles to simultaneously enter the roundabout (one to turn southbound toward Button Junction, the other to travel around the roundabout to go northbound).

The FHWA report "Roundabout: An Informational Guide" suggests that the roundabout design problem is essentially one of determining a design that will accommodate the traffic demand while minimizing some combination of delay, crashes and costs to all users. In the selection of an appropriate traffic control type for any intersection, it should be assumed that the minimization of a combination of delay, crashes and costs should be the primary measure of effectiveness. Although, this study did not analyze any crash data to reflect crash reduction benefits from constructing roundabouts, many studies conducted in the past have shown that for single-lane urban stop-controlled intersection overall crash reduction of more than 60% can be achieved after constructing roundabouts at such locations. For signalized intersections, such conversions have shown an overall crash reduction of more than 30%.

REFERENCES

1. Kittelson & Associates, Inc. *Roundabouts: An Informational Guide*. Report FHWS-RD-00-067. FHWA, U.S. Department of Transportation, 2000.I am at
2. Parsons Brinkerhoff, Inc. *SR-35 Columbia River Crossing Traffic Study*. Southwest Washington Regional Transportation Council, Oregon Department of Transportation, and Washington State Department of Transportation, 2003.
3. Institute of Transportation Engineers (ITE). *Trip Generation, Volumes 1-3*. 7th Edition.
4. Z.Z. Tian, T. Urbanik II, R. Engelbrecht, and K. Balke. Variations in Capacity and Delay Estimates from Microscopic Traffic Simulation Models. In *Transportation Research Record 1802*, TRB, National Research Council, Washington, D.C., 2002, pp. 23-31.
5. *Synchro Check List*. Transportation System Analysis Unit, Transportation Development Division, Oregon Department of Transportation.

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APPENDIX B. ASSUMTIONS FOR THE STUDY

Base Year and 2025 Volumes

For the current study, base year volumes were available for the PM peak hour for two SR-35/I-84 intersections. Base year traffic data for West Marina Drive-Market Place/SR-35 intersection were estimated using the ITE Trip Generation Manual. Based on the types of land-uses for West Marina Drive and the Market Place as well as our familiarity with the area, the trip distributions worked out to be as follows:

- Market Place at SR-35: 313 IN, 312 OUT.
- Marina Drive at SR-35: 46 IN, 30 OUT.

Minor adjustments were completed to balance the traffic for the I-84 ramp intersections, West Marina Drive, Market Place and the toll booth. Analysis year 2025 traffic forecasts were estimated using a growth rate of 3.5% per year for both eastbound and westbound SR-35/I-84 intersections based on the projected growth between year 2000 and year 2020 from previous work completed. Future volumes for the Market Place were assumed to be constant with respect to the base year and that for the West Marina Drive were assumed to grow at approximately half the rate of I-84/SR-35 intersections. It was assumed that land-use for the Market Place will remain the same due to lack of buildable land. No additional retailers/other land-uses could be accommodated there.

Traffic Composition and PHFs

Based on the Hood River Bridge Origin and Destination Survey of 1990, traffic composition for the study area (excluding West Marina Drive approach) was retained at 8% heavy vehicles that included trucks, buses, RVs, or campers. The following assumptions were made:

- Of 8% heavy vehicles, 7% would be single-unit trucks or buses and 1% trucks with trailers or RVs.
- Since traffic composition for the West Marina Drive approach (Port entry) does not include much heavy vehicle traffic, a 2% ratio was used for this approach with 1% being single-unit trucks or buses and 1% trucks with trailers or RVs.
- The Peak Hour Factor (PHF) for the study area, excluding West Marina Drive and Market Place approaches was assumed to be 0.90.
- West Marina Drive and Market Place approaches were analyzed with a PHF of 0.85.

The assumptions utilized in the study are in accordance with the ODOT requirements for traffic analysis using Synchro/SimTraffic (*5*).

2025 Alternatives

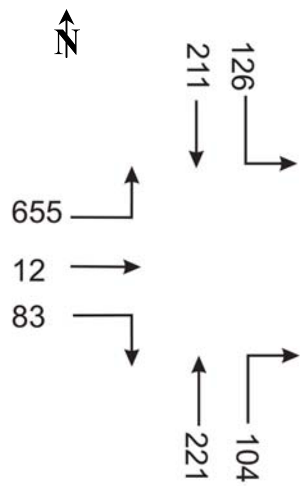
The "No-Build 2025" alternative matched base year assumptions, except for the private driveway that was assumed closed. The first "build" alternative assumed signalized ramp intersections and assumed that the I-84 eastbound and westbound on- and off- ramps and SR-35 will function as two signalized intersections and the West Marina Drive/retail access and SR-35 will be retained as an All Way Stop Controlled intersection. It was also assumed that the I-84 eastbound on- and off- ramps will be realigned with SR-35 to function as one signalized intersection. Since HCS-2000 does not allow for three-legged unsignalized intersection analysis, northbound right and through lanes at SR-35 and West Marina Drive (Port Entry)/retail access intersection were analyzed as a single lane in HCS. Of all the intersections studied, only this intersection approach had a 3-legged All Way Stop Controlled configuration.

Under the second “build” alternative, two roundabouts were assumed, one for I-84 eastbound ramps and SR-35, and another that connected the I-84 westbound ramps, West Marina Drive (Port Entry), retail access and SR-35. The roundabout design and micro-simulation assumed a design speed of 20 mph.

APPENDIX C. ROUNDABOUTS CAPACITY CALCULATIONS USING FHWA's METHODOLOGY

I-84 Eastbound Roundabout

The graphic below shows Year 2025 hourly volumes (V_{vph}) at the I-84 eastbound ramp intersection. The following steps were taken to estimate roundabout approach capacities:



Side Street (EB Off-Ramp)

Main Street (SR-35)

Step 1: Convert Hourly Volumes to Passenger Car Equivalents (PCE) Using Equation $V_{pcph} = V_{vph} [f_{HV}]$ and Exhibit 4-1 of FHWA's "Roundabout: An Informational Guide".

Example: EB Through = 12 vph

% Cars (0.92) × 1.0 pce/vehicle = 0.92

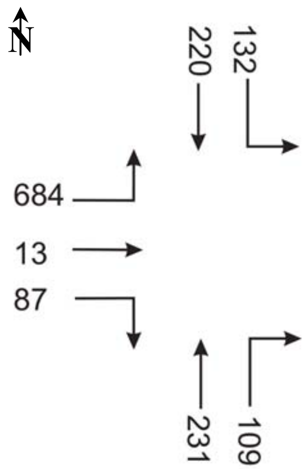
% SU/Bus (0.07) × 1.5 pce/vehicle = 0.105

% Combo (0.01) × 2.0 pce/vehicle = 0.02

f_{HV} = 1.045

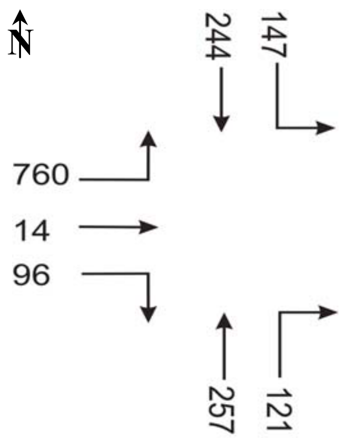
V_{pcph} = 1.045 × 12 = 13 pce

Similarly, all volumes were converted to pce as shown below:



Step 2: Peak Hour Factor (PHF) Conversion:

Volume in pce (V_{pcph}) were converted to peak 15-minute flow rates using PHF of 0.90 for all movements. The final flow rates in pcph are shown in graphic below:



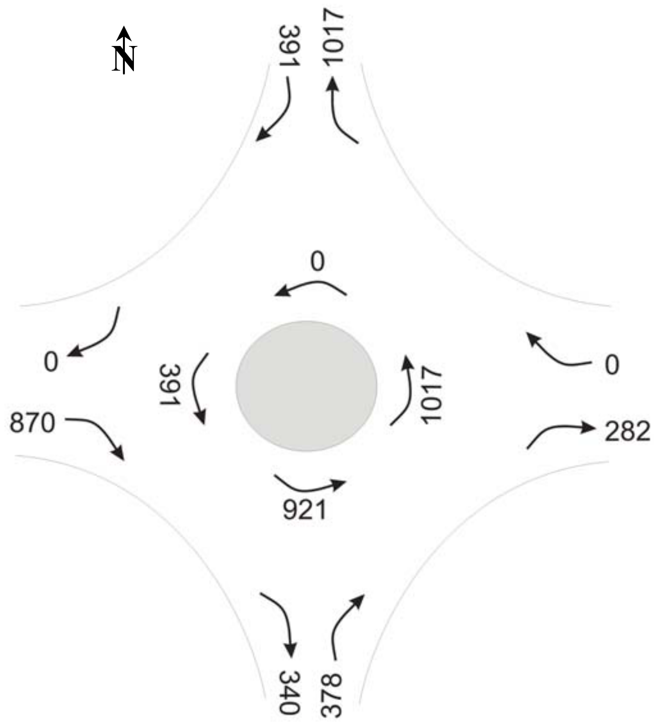
Step 3: Capacity Calculation

For intersection volumes obtained in Step 2, entering, exiting and circulatory volumes were calculated for a roundabout as shown below. Entering, exiting and circulatory volumes were calculated obtained using Equations 4-1 to 4-6 of FHWA's "Roundabout: An Informational Guide". The capacity of each approach could now be calculated as follows:

Eastbound Approach:

- Entering Volume = 870 pce/h
- Circulatory Volume = 391 pce/h
- Using Exhibit 4-3, capacity of EB entry = 1005 pce/h
- Volume-to-Capacity ratio = 870/1005 = 0.86 > 0.85, the acceptable threshold for roundabouts.

∉ Using Exhibit 4-6, capacity of EB entry if flared w/2 vehicle short leg = 1720 pce/h
∉ Volume-to-Capacity ratio = 870/1720 = 0.50 < 0.85, the acceptable threshold for roundabouts.



Northbound Approach:

∉ Entering Volume = 378 pce/h
∉ Circulatory Volume = 921 pce/h
∉ Using Exhibit 4-3, capacity of NB entry = 706 pce/h
∉ Volume-to-Capacity ratio = 378/706 = 0.53 < 0.85, the acceptable threshold for roundabouts.

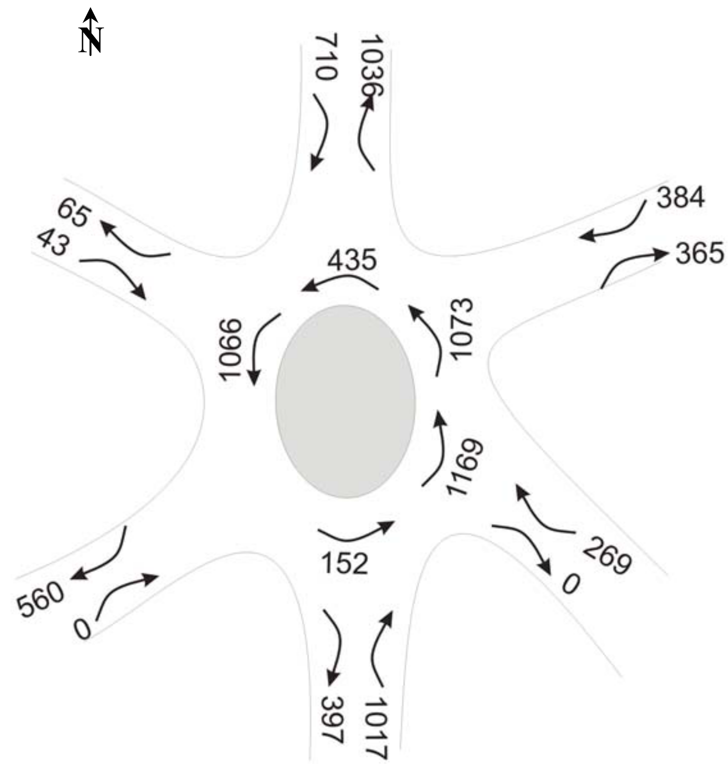
Southbound Approach:

∉ Entering Volume = 391 pce/h
∉ Circulatory Volume = 0 pce/h (assumed 1 pce/h for calculations)
∉ Using Exhibit 4-3, capacity of SB entry = 1220 pce/h
∉ Volume-to-Capacity ratio = 391/1220 = 0.32 < 0.85, the acceptable threshold for roundabouts.

Result: The EB off-ramp is the critical approach which will operate at slightly over capacity in 2025 with a single-lane roundabout. This problem could be solved with flaring the approach to accommodate a 2-vehicle short lane.

I-84 Westbound Oval Roundabout

Using steps 1-3 as identified for the I-84 Eastbound roundabout, the following graphic shows the entry, exit and circulatory volumes for the oval roundabout.



Note that for the West Marina Drive/Port approach, 1% SU/Bus and 1% Combo was used. Also a PHF of 0.85 was used for West Marina Drive/Port and Retail Access. The capacity analysis is shown below:

Northbound Approach (SR-35):
- Entering Volume = 1017 pce/h
- Circulatory Volume = 152 pce/h
- Using Exhibit 4-3, capacity of NB entry = 1145 pce/h
- Volume-to-Capacity ratio = 1017/1145 = 0.88 > 0.85, the acceptable threshold for roundabouts.
- Using Exhibit 4-6, capacity of NB entry if flared w/2 vehicle short leg = 1845 pce/h
- Volume-to-Capacity ratio = 1017/1845 = 0.55 < 0.85, the acceptable threshold for roundabouts.

North-Westbound Approach (WB I-84 Off-ramp):
- Entering Volume = 269 pce/h
- Circulatory Volume = 1169 pce/h
- Using Exhibit 4-3, capacity of SB entry = 575 pce/h
- Volume-to-Capacity ratio = 269/575 = 0.47 < 0.85, the acceptable threshold for roundabouts.

South-Westbound Approach (Retail Access):

- Entering Volume = 384 pce/h
- Circulatory Volume = 1073 pce/h
- Using Exhibit 4-3, capacity of SB entry = 630 pce/h
- Volume-to-Capacity ratio = 384/630 = 0.61 < 0.85, the acceptable threshold for roundabouts.

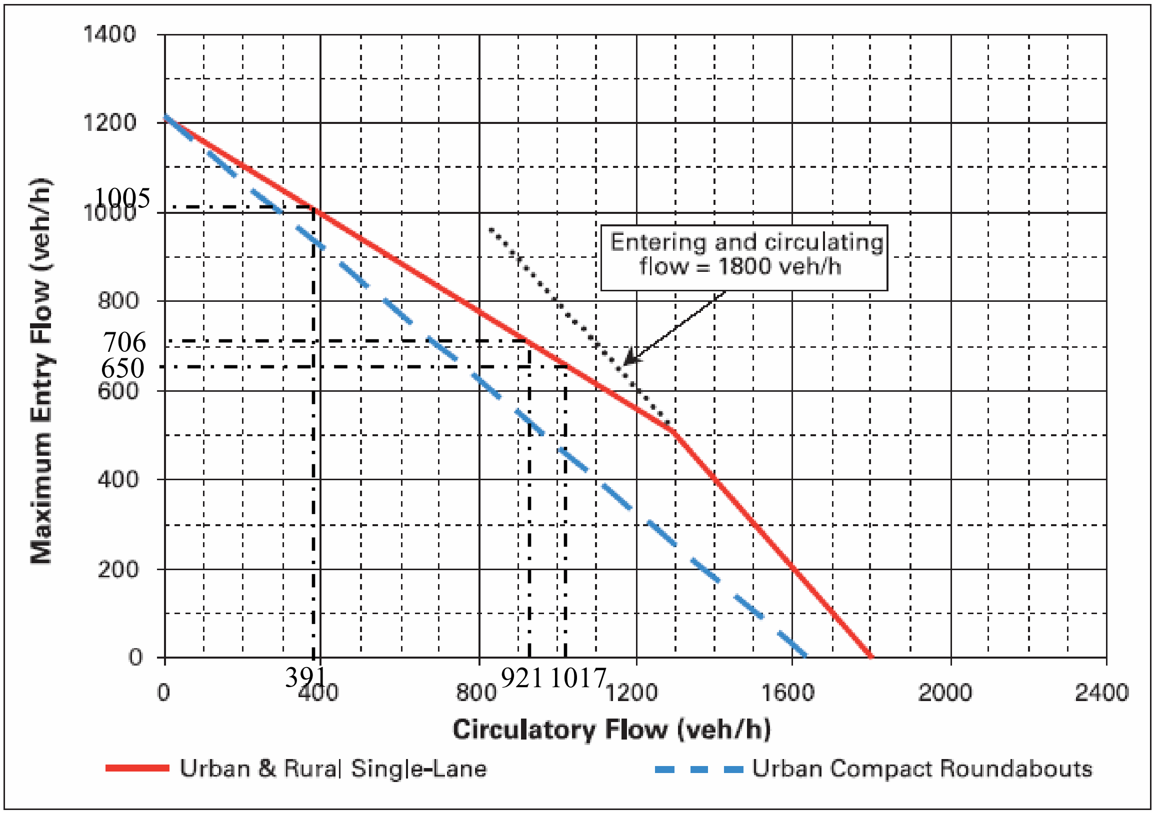
Southbound Approach (SR-35):

- Entering Volume = 710 pce/h
- Circulatory Volume = 435 pce/h
- Using Exhibit 4-3, capacity of SB entry = 975 pce/h
- Volume-to-Capacity ratio = 710/975 = 0.73 < 0.85, the acceptable threshold for roundabouts.

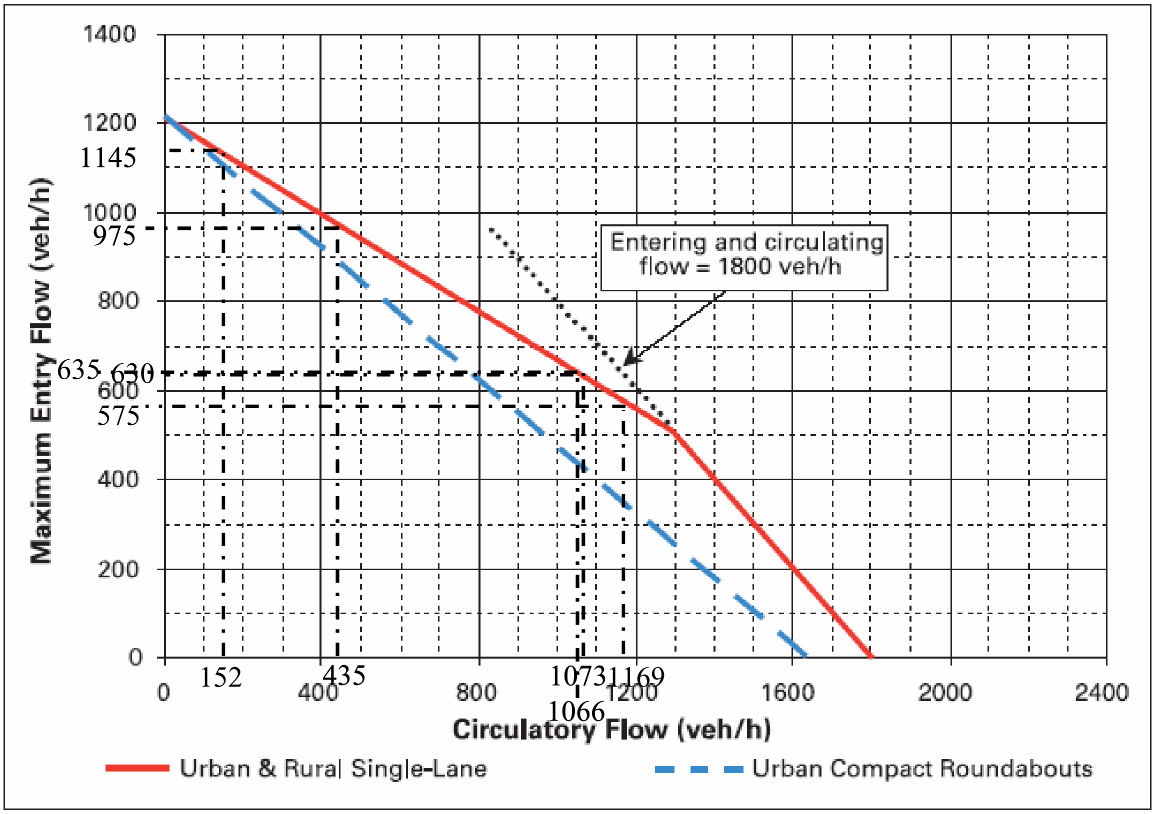
South-Eastbound Approach (West Marina Drive/Port Access):

- Entering Volume = 43 pce/h
- Circulatory Volume = 1066 pce/h
- Using Exhibit 4-3, capacity of SB entry = 635 pce/h
- Volume-to-Capacity ratio = 43/635 = 0.07 < 0.85, the acceptable threshold for roundabouts.

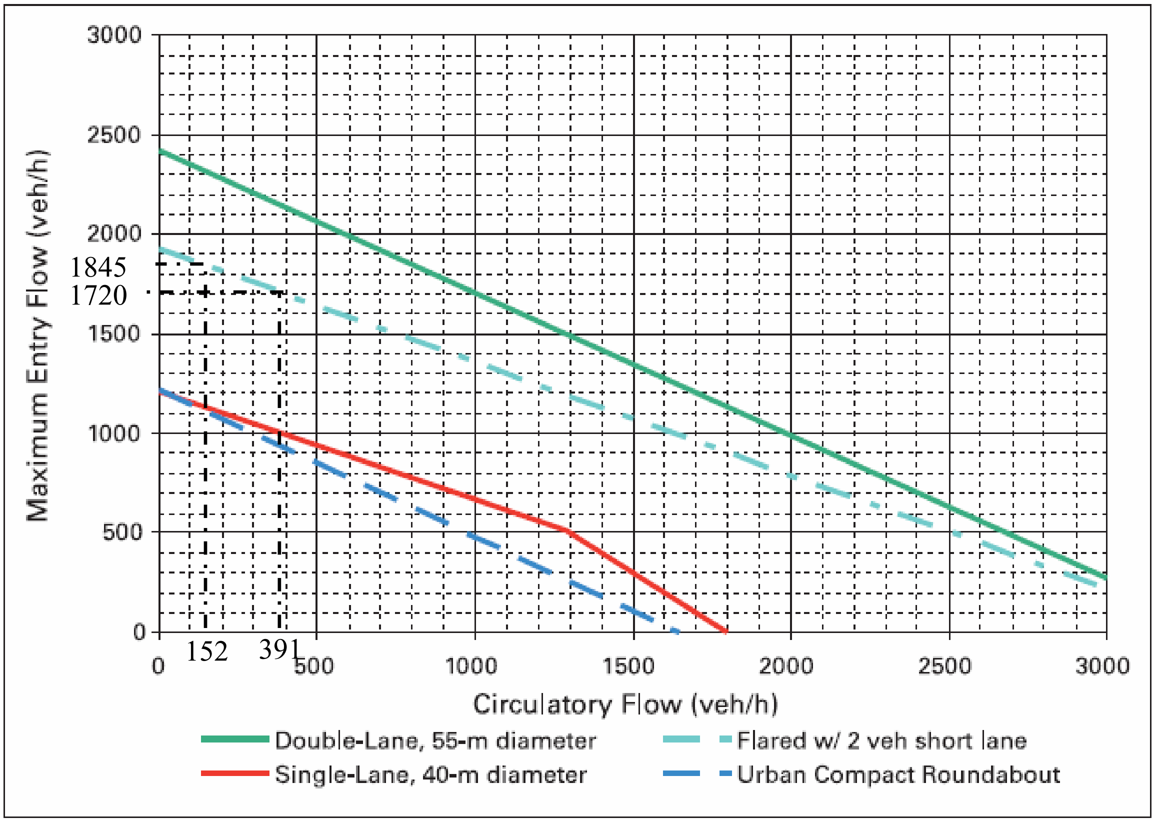
Result: The NB approach (SR-35) is the critical approach which will operate slightly overcapacity in 2025 with a single-lane roundabout. This problem could be solved with flaring the approach to accommodate a 2-vehicle short lane.



Single-Lane Roundabout (Exhibit 4-3, p. 87 in "Roundabout: An Informational Guide") Showing Capacity for I-84 Eastbound Ramps and SR-35



Single-Lane Roundabout (Exhibit 4-3, p. 87 in "Roundabout: An Informational Guide")
Showing Capacity for I-84 Westbound Ramps, Retail-Port Access, and SR-35



Flared Approach Roundabout (Exhibit 4-6, p. 89 in "Roundabout: An Informational Guide") Showing Capacity Increase for I-84 and SR-35 Roundabout Critical Approaches

APPENDIX D. ROUNDABOUT COSTS

CONCEPTUAL COST ESTIMATE
Summary of Alignments - Short Term Options
(2002 Dollars in Millions)

June 2004 Cost Estimate	
$0.00	Toll Facility (cost deleted)
$0.02	Modify Driveway
$0.08	Sidewalks/Shoulders
$0.35	Roundabouts
$0.17	Additional ROW and increased cost for oversized roundabout
$0.62	**Subtotal1**
$0.19	Contingencies: 30%
$0.80	**Subtotal2**
$0.08	Engineering: 10%
$0.09	Construction Mgmt: 15%
$0.98	**Total Project Cost (June 2004)**

Revised: June 24, 2004

Note: Cost above does not include any allowance for Environmental Mitigation.